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Outcomes of Thoracic Endovascular Aortic Repair and Subclavian Revascularization Techniques

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Abstract

Background—Practice guidelines regarding management of the left subclavian artery (LSA) during thoracic endovascular aortic repair (TEVAR) are based on low quality evidence and there is limited literature that addresses optimal revascularization techniques. The purpose of this study is to compare outcomes of LSA coverage during TEVAR and revascularization techniques.

Study Design—We performed a single-center retrospective cohort study from 2001–2013. Patients were categorized by LSA revascularization and by revascularization technique, carotid-subclavian bypass (CSB) or subclavian-carotid transposition (SCT). Thirty-day and mid-term stroke, spinal cord ischemia, vocal cord paralysis, upper extremity ischemia, primary patency of revascularization, and mortality were compared.

Results—Eighty patients underwent TEVAR with LSA coverage, 25% (n=20) were unrevascularized and the remaining patients underwent CSB (n=22, 27.5%) or SCT (n=38, 47.5%). Mean follow-up time was 24.9 months. Comparisons between unrevascularized and revascularized patients were significant for a higher rate of 30-day stroke (25% vs. 2%, p=0.003) and upper extremity ischemia (15% vs. 0%, p=0.014). However, there was no difference in 30-day or mid-term rates of spinal cord ischemia, vocal cord paralysis, or mortality. There were no statistically significant differences in 30-day or midterm outcomes for CSB vs. SCT. Primary patency of revascularizations was 100%. Survival analysis comparing unrevascularized vs. revascularized LSA, was statistically significant for freedom from stroke and upper extremity

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ischemia, $p=0.02$ and $p=0.003$, respectively. After adjustment for advanced age, urgency and coronary artery disease, LSA revascularization was associated with lower rates of peri-operative adverse events (OR 0.23, $p=0.034$).

Conclusions—During TEVAR, LSA coverage without revascularization is associated with an increased risk of stroke and upper extremity ischemia. When LSA coverage is required during TEVAR, CSB and SCT are equally acceptable options.

In the United States prior to the early 2000s, diseases of the thoracic aorta were treated with open repair.(1) Open repair is associated with significant risk of perioperative morbidity and mortality, with estimated mortality rates from 6.6%–19%.(2–4) The development of thoracic endovascular aortic repair (TEVAR), a less invasive technique, has resulted in reduced operative time, length of stay, improved perioperative morbidity, and mortality rates as low as 2.1%.(2) As the utilization of TEVAR has increased, it has been applied to a wider range of pathology, including aneurysms, dissections, and traumatic aortic injury. (5, 6)

Though TEVAR has dramatically altered the treatment of thoracic aortic pathology, it is not free of limitations. One key limitation is the necessity of adequate, disease-free seal zones for the endovascular stent-graft in the proximal and distal aorta. The proximal seal zone beyond the left subclavian artery (LSA) is estimated to be of inadequate length in 26–40% of patients with disease of the descending thoracic aorta.(7, 8) In these cases, achievement of an adequate proximal seal zone for endograft requires coverage of the LSA. Coverage of the LSA is associated with increased risk of stroke, spinal cord ischemia, and upper extremity ischemia. (5)

In 2010 the Society of Vascular Surgery (SVS) published updated recommendations regarding coverage of the LSA during TEVAR. These recommendations noted that in non-urgent cases the LSA should be revascularized before TEVAR, and in urgent cases the decision to revascularize can be made after TEVAR is performed. However, the SVS report noted that their recommendations were based on low quality evidence.(7) Further, the recommendations did not address the most effective techniques for LSA revascularization.

The purpose of this study is to compare 30-day and mid-term outcomes of LSA coverage during TEVAR and to evaluate revascularization techniques for the LSA. We hypothesized that maintaining LSA patency would have improved outcomes, and that the two most common revascularization techniques, carotid-subclavian bypass (CSB) and subclavian-carotid transposition (SCT), would have similar 30-day and mid-term outcomes.

METHODS

Study Design

This was a single-center retrospective cohort study that evaluated all cases of TEVAR with LSA coverage at a tertiary academic urban referral center from January 2001 to December 2013. Electronic medical records were reviewed to obtain patient demographics, peri-procedural information, and associated outcomes data. The Northwestern University Institutional Review Board approved this study and patient consent was waived.

Patients

Adult patients age 18–99 were identified using the following Current Procedural Terminology (CPT) code combinations: TEVAR with subclavian artery coverage (33880), TEVAR with subclavian artery coverage and carotid- subclavian bypass (CSB) (33880+35606), and TEVAR with subclavian artery coverage and subclavian-carotid transposition (SCT) (33880+33889). The selected study period was chosen based on the availability of electronic health records and when the procedures were performed with increased frequency. Both elective and emergent cases were included in the sample. The comparison groups were designated by exposure criteria. The first comparison groups were unvascularized LSA vs. revascularized LSA. The second groups were based on revascularization types, CSB vs. SCT.

Demographic and Procedural Data

Collected variables were categorized as demographic and pre-operative (i.e. age, sex, comorbidities, presence or absence of symptoms, procedure urgency), intra-operative (i.e. graft type, lumbar drain, completion angiogram, revascularization timing), and post-operative outcomes (stroke, spinal cord ischemia, upper extremity ischemia, vocal cord paralysis, primary patency and mortality). Study follow-up time was defined as the date of last postoperative clinical evaluation. Most patients underwent postoperative surveillance imaging at 1-month, 6-months, and then annually. Additionally, all available postoperative imaging results were reviewed, which included thoracic computerized tomographic angiography (CTA) and thoracic magnetic resonance imaging (MRA) performed within the NMH system and as well as those performed at outside facilities, when available.

Preoperative Imaging and Revascularization Decision

There was no institutional protocol to determine which cases required revascularization of the LSA, however general principles of revascularization included patent coronary artery bypass graft (CABG), occluded right vertebral artery and dominant left vertebral artery. Thoracic aortic pathology was diagnosed by computerized tomographic angiography (CTA). The proximal vertebral arteries were imaged on all CTAs, however, preoperative imaging of cerebral anatomy was not performed routinely. Choice of revascularization technique was determined by patient anatomy and physician preference. For all CSB cases, proximal occlusion was performed via catheter-based coil embolization or plugs.

Outcomes

The outcomes of interest were stroke, spinal cord ischemia, upper extremity ischemia, vocal cord paralysis, graft primary patency, and mortality. All were assessed clinically within 30-days after TEVAR and at mid-term follow-up. The latter was defined as greater than 30 days and less than 5 years. Diagnosis of suspected perioperative/postoperative stroke and spinal cord ischemia were confirmed with computed tomography (CT) and/or magnetic resonance imaging (MRI), as well as documentation from consulting specialties (i.e. neurology) and discharge diagnoses. Diagnosis of vocal cord paralysis was based on clinical suspicion and confirmed with fiberoptic laryngoscopy and otolaryngology consultation. All-cause mortality was determined by institutional updates through the Social Security

Administration-Death Master File (SSA-DMF), which was current through March 21, 2014. The SSA-DMF did not include cause of death and cause of death was not universally available in the electronic medical records.

In accordance with the Society of Vascular Surgery reporting guidelines for TEVAR and endovascular aortic aneurysm repair (EVAR), stroke, spinal cord ischemia, upper extremity ischemia, and vocal cord paralysis complications were graded by severity (Table I). Higher grade indicated more “severe” morbidity and mortality(9, 10). Additionally, stroke was categorized by cerebral vascular territory (anterior, posterior, or multi-territory).

Statistical analysis

Descriptive statistics were used to evaluate demographic information, preoperative, intraoperative, and outcome variables. Chi-squared or Fisher exact tests, were used to measure associations between exposure variables and demographic variables and between exposure variables outcome variables. Survival analysis was performed to estimate stroke, upper extremity ischemia, and all-cause mortality. To determine predictors of adverse peri-operative events (stroke, spinal cord ischemia, upper extremity ischemia, and mortality), we performed a multivariate stepwise logistic regression. All analyses were performed using STATA software version 13.0 (College Station, Texas). Statistically significant values were noted if $p < 0.05$.

RESULTS

Demographics and Procedure Characteristics

From 2001–2013, a total of 231 TEVARs were performed, of which 80 (35%) required coverage of the LSA. The 80 patients with LSA coverage had a mean age of 59.9 years, and 70% ($n=56$) were male. The LSA was unrevascularized in 25% ($n=20$) and revascularized in 75% ($n=60$). The revascularized group included 37% CSB ($n=22$) and 63% SCT ($n=38$). Indications for TEVAR included aneurysm 36% ($n=29$), dissection 40% ($n=32$), pseudoaneurysm 16% ($n=13$), and traumatic aortic injury 8% ($n=6$). Elective cases accounted for 53% ($n=42$) of the sample, while urgent and emergent were 19% ($n=15$) and 29% ($n=23$), respectively. 74% of emergent cases were hospital transfers.

Demographics were similar between the unrevascularized and revascularized groups except for age, history of coronary artery disease, and procedure urgency. The revascularized group had a significantly higher proportion of patients older than 50 years of age ($p=0.037$) and patients with coronary artery disease ($p=0.026$). The unrevascularized group was more likely to have undergone TEVAR for urgent or emergent cases ($p=0.001$). Demographics were similar between CSB and SCT groups except that CSB patients were more likely to have a history of coronary artery disease (55% vs. 26%, $p=0.029$) and coronary artery bypass graft (CABG) (32% vs. 5%, $p=0.009$) (Table II). Amongst the revascularized patients, 58% ($n=35$) underwent revascularization prior to TEVAR, and median time to TEVAR was 5 days (interquartile range, 1–19 days). The remaining patients had LSA revascularization during TEVAR, 42% ($n=25$). Within the unrevascularized group, 20% ($n=4$) underwent delayed revascularization for upper extremity ischemia.

Outcomes

Mean follow-up time was 24.9 months. Strokes occurred in 10% of patients (n=8), of which, 38% (n=3) were in the posterior circulation, 25% (n=2) anterior circulation, and 38% (n=3) multi-territory. Of note, anterior and posterior strokes ranged in grade severity from 2 to 3, signifying permanent mild to severe impairment, respectively. While 66% (n=2) of multi-territory strokes were grade 1 with symptoms that resolved in less than 24 hours.

Spinal cord ischemia developed in 4% of patients (n=3), of which 33% (n=1) was severity grade 3B, and 67% (n=2) were severity grade 3C. There were 6% (n=5) that developed upper extremity ischemia. All cases of upper extremity ischemia were of severe grade, and 4 of 5 cases resulted in reoperation for LSA revascularization. Patients that underwent delayed revascularization had resolution of extremity ischemia without additional complications. The one case that did not undergo delayed LSA revascularization was because of high illness acuity. That patient subsequently required left upper extremity amputation secondary to gangrene and clinical deterioration. Vocal cord paralysis was detected in 8% of patients (n=6) and 50% were mild grade and 50% were moderate. Two patients with moderate vocal cord paralysis required vocal cord medialization secondary to persistent hoarseness. Thirty-day all-cause mortality was 3% (n=2), and 14% (n=11) at midterm for the sample.

The indications for TEVAR were aneurysm, dissection, pseudoaneurysm and traumatic aortic injury. Comparison of overall study outcomes stratified by indication for TEVAR showed no difference for stroke, spinal cord ischemia, upper extremity ischemia, vocal cord paralysis or mortality (Table III).

Unrevascularized vs. Revascularized

Comparisons between the unrevascularized and revascularized group were significant for a higher rate of 30-day stroke and upper extremity ischemia, (25% vs. 2%, $p=0.003$) and (15% vs. 0%, $p=0.014$), respectively. However, at mid-term these differences were no longer statistically significant. For the remaining outcomes, spinal cord ischemia, vocal cord paralysis, and mortality were not statistically significant at 30-day or mid-term (Table IV). Additional evaluation of staged LSA revascularization, as a separate procedure prior to TEVAR vs. concurrently on the same day as the TEVAR, was not statistically significant for mortality, upper extremity ischemia, or neurologic complications (data not shown).

Carotid-Subclavian Bypass vs. Subclavian-Carotid Transposition

Comparison of 30-day and midterm outcomes, stroke, spinal cord ischemia, upper extremity ischemia, vocal cord paralysis, and mortality, for CSB vs. SCT showed no statistically significant difference. Though not statistically significant, vocal cord paralysis was more prevalent with SCT at 30-days (11% vs. 5%, $p=0.643$). Primary patency of revascularization was 100% for both groups (Table V).

Survival Analysis

Kaplan-Meier (KM) estimates, stratified by procedure, were performed for stroke, upper extremity ischemia, and survival. Stroke estimates were statistically significant for unrevascularized LSA (76% at 1 and 3 years) and SCT (95% at 1 year and 88% at 3 years)

(Figure 1). Upper extremity ischemia estimates were statistically significant for unrevascularized LSA, (78% at 1 year and 3 years) with no events of upper extremity ischemia for CSB and SCT groups (Figure 2). Survival estimates did not reach significance for unrevascularized LSA, CSB or SCT, $p=0.86$ (Figure 3).

Multivariate Analysis

To determine predictors of adverse peri-operative events (stroke, spinal cord ischemia, upper extremity ischemia, and mortality), we performed a multivariate stepwise logistic regression. We found that revascularization was associated with lower rates of peri-operative adverse events (OR 0.23, $p=0.034$) after adjustment for urgency of operation, advanced age, and coronary artery disease (Table VI).

DISCUSSION

Our study demonstrates a number of important findings in patients that underwent TEVAR with coverage of the LSA without revascularization. First, there was a higher rate of stroke and upper extremity ischemia compared to patients that had LSA revascularization. Second, both stroke and upper extremity ischemia complications led to permanent neurologic and/or motor disability. Furthermore, CSB and SCT were equivalent in terms of stroke, upper extremity ischemia, spinal cord ischemia, primary patency of revascularization, and mortality, at 30-days and mid-term. Vocal cord paralysis occurred more commonly in SCT, but this difference was not statistically significant.

There was a lower rate of LSA revascularization in the urgently treated patients in our cohort. Urgency was associated with higher rates of post-operative events (70% vs. 30%, $p=0.02$), however the association was no longer present on multivariable analysis. After adjustment for urgency of operation, advanced age, and coronary artery disease, LSA revascularization was the only significant predictor of post-operative complications (OR 0.23, $p=0.034$). The current study had a decreased incidence of 30-day stroke, with LSA revascularization, 25% vs. 2%. One-third ($n=2$) of strokes in the unrevascularized group were in the posterior circulation, suggesting ischemia due to loss of vertebral blood flow. While an embolic etiology is suspected for anterior circulation and multi-territory strokes in these patients, our data demonstrates an elevated risk of all-cause stroke with LSA coverage in the absence of revascularization. Prior literature demonstrated similar reductions in stroke events with the implementation of LSA revascularization (6, 11). For example, Feezor et al described their experience with TEVAR and LSA coverage, and noted a reduction in stroke events from 6% down to 2% with selective revascularization. However, our results are in contrast to a contemporary study by Maldonado et al (12), that evaluated selective LSA revascularization during TEVAR patients with thoracic aortic aneurysm. This study noted a stroke rate of approximately 6%, with no difference in stroke outcomes with or without revascularization. The differences in stroke rate may be due to differences in patient selection compared to our sample. Similar to Maldonado et al, we performed selective revascularization in emergent cases and we were more likely to perform LSA revascularization in elective cases.

Revascularization technique, CSB and SCT, did not reveal any significant differences in stroke incidence in our sample, which was consistent with prior literature(13). Based on our results, and the majority of literature in this area, stroke is a prominent complication with coverage of the LSA and revascularization should be considered. Proper patient selection for LSA revascularization in the setting of urgent and emergent TEVAR remains incompletely delineated in our study and others.

Upper extremity ischemia for unrevascularized vs. revascularized patients was also significant, not only statistically, but also because of the morbidity associated with this outcome. In our study population, when upper extremity ischemia occurred it resulted in reoperation or limb amputation 100% of the time. However, a recent study and the Society of Vascular Surgery guidelines note that upper extremity ischemia is a rare occurrence and has no impact on quality of life (8, 14). Our revascularization group had no events of upper extremity ischemia, and the same was true in the cited studies.

Vocal cord paralysis was seen more frequently in SCT (13%, n=5) compared to CSB patients (5%, n=1), particularly during the earlier years in our series. However, the rate of vocal cord paralysis was relatively low in the context of all procedures (8%). The operative exposure required when performing an SCT places the vagus nerve at risk of injury due to medial retraction (15). Although the patients in our sample experienced mild to moderate severity of symptoms with no airway compromise, a rate of 8% suggests the importance of maintaining a high clinical suspicion for vocal cord paralysis in patients undergoing SCT.

Primary patency of revascularization was 100% in our sample. In contrast, a prior study and systematic review concluded that SCT compared to CSB had superior patency (84% vs. 98%) and freedom from complications (88 vs. 99%) (16). A potential explanation of these differences is that the aforementioned study evaluating LSA revascularization had a heterogeneous cohort of both patients undergoing TEVAR and patients undergoing treatment for LSA occlusive disease (6, 16–19). A notable difference in our comparison groups was the expected distribution that CSB patients had a higher incidence of CABG, because the presence of a functioning internal mammary CABG is a crucial indication to select CSB over SCT. When CSB is performed, LSA clamping occurs more distal, thus preserving CABG blood flow (15, 20).

In the entire cohort, the reported all-cause mortality rate was 16% based on the SSA-DMF report through March 2014. Although the report is accurate for survival its use for cause of death is not possible. Thus, final conclusions regarding aortic- or LSA-related mortality are limited.

A key strength of our research was the ability to evaluate patients over a longer period of time through the use of robust single-center electronic medical records. However, this study does have notable limitations. First, although the sample was selected over a 12-year time interval, the frequency with which TEVAR with coverage of the LSA is performed limits the sample size and potentially underpowers our results. Second, due to non-randomization and a retrospective design, the study is subject to inherent bias and confounding.

CONCLUSIONS

Based on our results, left subclavian artery coverage during TEVAR without revascularization is associated with an increased risk of cerebrovascular events and upper extremity ischemia. When LSA coverage is required during TEVAR, carotid-subclavian bypass (CSB) or subclavian-carotid (SCT) have similar outcomes and should be performed.

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Abbreviations

LSA	left subclavian artery
TEVAR	thoracic endovascular aortic repair
CSB	carotid-subclavian bypass
SCT	subclavian-carotid transposition

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Figure 1.

Kaplan-Meier estimates for stroke, stratified by procedure. The unrevascularized group had a higher risk of stroke at 1 and 3 years, compared to carotid-subclavian bypass (CSB) and subclavian-carotid transposition (SCT).

Figure 2.

Kaplan-Meier estimates for upper extremity ischemia, stratified by procedure. The unrevascularized group had a higher risk of upper extremity ischemia at 1 and 3 years, compared to carotid-subclavian bypass (CSB) and subclavian-carotid transposition (SCT).

Figure 3.

Kaplan-Meier estimates for survival, stratified by procedure. There was no significant difference for all three groups. CSB, carotid-subclavian bypass; SCT, subclavian-carotid transposition.

Table 1**Thoracic Endovascular Aortic Repair Complication Grading System**

Complication and grade	Criteria
Cerebrovascular	
1	Deficit lasting less than 24 hours
2	Delayed recovery, image confirmed infarct (CT or MRI), permanent mild impairment
3	Severe impairment or fatal outcome
Upper extremity ischemia or vocal cord paralysis	
Mild	Spontaneous resolution or with minimal intervention, no permanent impairment, did not extend hospital stay
Moderate	Required significant intervention, increased hospitalization >24hours, minor permanent disability that does not affect normal daily activity
Severe	Required major surgical or medical intervention, prolonged or permanent disability, and/or resulting in death
Spinal cord ischemia	
0	None
1	Minimal sensory deficit, ambulates independently
2	Minor motor deficit, ambulates with assistance or independently (can move against gravity)
3a	Nonambulatory, can move against gravity
3b	Nonambulatory, cannot move against gravity
3c	Nonambulatory, minimal or no movement

(Adapted from Society of Vascular Surgery Reporting Guidelines for endovascular aneurysm repair [EVAR] and thoracic endovascular aortic repair [TEVAR] (9, 10), with permission from the publisher of J Vasc Surg).

Table 2

Patient Demographics and Characteristics, Stratified by Procedure

Variables	Overall n=80	Unrevascularized (n=20)	Revascularized (n=60)	p Value*	CSB (n=22)	SCT (n=38)	p Value*
Male, n (%)	56 (70.0)	16 (80.0)	40 (66.7)	0.399	16(72.73)	24(63.16)	0.449
Age, y				0.037 [†]			0.357
<50	17 (21.25)	8(40.00)	9(15.00)		2(9.09)	7(18.42)	
50-64	32(40.00)	9(45.00)	23(38.33)		9(40.91)	14(36.84)	
65-79	23(28.75)	2(10.00)	21(35.00)		10(45.45)	11(28.95)	
>80	8(10.00)	1(5.00)	7(11.67)		1(4.55)	6(15.79)	
White	40 (50.00)	7 (35.00)	33 (55.00)	0.196	12(54.55)	21(55.26)	1.000
Obese	17 (29.82)	7(31.82)	10(28.57)	1.000	7(31.82)	9(26.47)	0.665
Smoking	43(58.90)	8(50.00)	35(61.4)	0.413	12(54.55)	23(65.71)	0.399
HTN	63 (78.50)	16 (80.00)	47 (78.3)	1.000	20(90.91)	27(71.05)	0.106
DM	13 (16.25)	1 (5.00)	12 (20.0)	0.167	4(18.18)	8(21.05)	1.000
CAD	24(30.00)	2(10.00)	22(26.67)	0.026 [†]	12(54.55)	10(26.32)	0.029 [†]
CABG	10(12.50)	1(5.00)	9(15.00)	0.437	7(31.82)	2(5.26)	0.009 [†]
TIA/CVA	9(11.25)	2(10.00)	7(11.67)	1.000	1(4.55)	6(15.79)	0.246
CHF	5(6.25)	2(10.00)	3(5.00)	0.594	2(9.09)	1(2.63)	0.548
COPD	9(11.25)	2(10.00)	7(11.67)	1.000	2(9.09)	5(13.16)	1.000
CRI/ESRD	21(26.25)	7(35.00)	14(23.33)	0.304	11(28.95)	14(23.33)	0.219
Urgency				0.001 [†]			0.404
Elective	42(52.50)	2(10.00)	40(66.67)		17(77.27)	23(60.53)	
Urgent	15(18.75)	4(20.00)	11(18.33)		3(13.64)	8(21.05)	
Emergent	23(28.75)	14(70.00)	9(15.00)		2(9.09)	7(18.42)	
Indication				0.001 [†]			0.669
Aneurysm	29(36.25)	3(15.00)	26(43.33)		11(50.00)	15(39.47)	
Dissection	32(40.00)	15(75.00)	17(28.33)		7 (31.82)	10(26.32)	
Pseudoaneurysm	13(16.25)	0	13(21.67)		3 (13.64)	10(26.32)	
TAI	6(7.50)	2(10.00)	4(6.67)		1 (4.55)	3(7.89)	

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* χ^2 or Fisher exact tests, when appropriate.
† Statistically significant values.
CSB, carotid-subclavian bypass; SCT, subclavian-carotid transposition; HTN, hypertension; DM, diabetes mellitus; CAD, coronary artery disease; CABG, coronary artery bypass graft; TIA/CVA, transient ischemic attack/ cerebrovascular accident; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; CRI/ESRD, chronic renal insufficiency, end-stage renal disease; TAI, traumatic aortic injury.

Table 3
Overall Study Outcomes, Stratified by Thoracic Endovascular Aortic Repair Indication

Outcome	Total (n=80), n (%)	Aneurysm (n=29), n (%)	Dissection (n=32), n (%)	Pseudoaneurysm (n=13), n (%)	TAI (n=6), n (%)	p Value *
Stroke	8 (10.00)	1 (3.45)	6 (18.75)	0	1 (16.67)	0.095
SCI	3 (3.75)	2 (6.90)	1 (3.12)	0	0	0.825
UE Ischemia	5 (6.25)	1 (3.45)	3 (9.38)	0	1 (16.67)	0.320
Vocal cord paralysis	6 (7.50)	3 (10.34)	1 (3.12)	1 (7.69)	1 (16.67)	0.353
Mortality	13 (16.25)	6 (20.69)	6 (18.75)	1 (7.69)	0	0.640

* χ^2 or Fisher exact tests, when appropriate.

SCI, spinal cord ischemia; UE, upper extremity; TAI, traumatic aortic injury.

Table 4

Outcomes for Thoracic Endovascular Aortic Repair with Unrevascularized and Revascularized Left Subclavian Artery

Outcomes	Unrevascularized	Revascularized	p Value *
30-Day outcome, n	20	60	
Stroke	5 (25.00%)	1 (1.67%)	0.003 [†]
SCI	1 (5.00%)	2 (3.33%)	1.000
UE Ischemia	3 (15.00%)	0	0.014 [†]
Vocal cord paralysis	0	5 (8.33%)	0.324
Death	2 (10.00%)	0	0.060
Midterm outcome, n	17	47	
Stroke	1 (5.88%)	1 (2.13%)	0.464
SCI	0	0	-
UE Ischemia	2 (11.76%)	0	0.067
Vocal cord paralysis	0	1 (2.13%)	1.000

* χ^2 or Fisher exact tests, when appropriate.

[†] Statistically significant values.

SCI, spinal cord ischemia; UE, upper extremity.

Table 5

Outcomes for Thoracic Endovascular Aortic Repair and Left Subclavian Artery Revascularization Techniques, Carotid-Subclavian Bypass, and Subclavian-Carotid Transposition

Outcomes	CSB (n=22)	SCT (n=38)	p Value*
30 Day, n	22	38	
Stroke	0	1(2.63%)	1.000
SCI	0	2(5.26%)	0.528
UE Ischemia	0	0	-
Vocal cord paralysis	1(4.55%)	4(10.53%)	0.643
Primary patency	22(100%)	38(100%)	-
Death	0	0	-
Midterm, n	15	32	
Stroke	0	1(3.12%)	1.000
SCI	0	0	-
UE Ischemia	0	0	-
Vocal cord paralysis	0	1(3.12%)	1.000
Primary patency	15(100%)	32(100%)	-

* χ^2 or Fisher exact tests, when appropriate.

CSB, Carotid-Subclavian Bypass; SCT, Subclavian-Carotid Transposition; SCI, spinal cord ischemia; UE, upper extremity.

Table 6

Multivariate Analysis for Predictors of Adverse Perioperative Events

Covariate	OR	95% Confidence Interval		p Value
LSA Revascularization	0.23	0.059	0.90	0.034*
Urgent/emergent	1.90	0.50	7.24	0.349
Age >65 y	2.60	0.71	9.49	0.149
CAD	0.44	0.098	2.00	0.289

Events included were stroke, spinal cord ischemia, upper extremity ischemia, and mortality.

* Statistically significant.

LSA, left subclavian artery; CAD, coronary artery disease.